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CREST - Centre for Renewable Energy and Sustainable Technologies

Barry Mc Carron, CREST South West College / Queens University Belfast
South West College , Technology & Skills Centre, Enniskillen, Northern Ireland
Phone: +44 (0) 28 6634 2301; barry.mccarron@swc.ac.uk

Introduction

CREST - Centre for Renewable Energy and Sustainable Technologies is led by South West College which is a Further and Higher Education College, located in the south west region of Northern Ireland. The college currently is developing towards being the Passive House Centre of Excellence for the Northern Ireland region. This is being achieved through the operation of the Centre, which provides passive house demonstration and offers the designers and tradesperson courses to local industry as part of wider research, across three main themes which are Sustainable Construction, Bio Energy and Energy Storage.

The Passive House Certified CREST Pavilion was completed in November 2014 with the purpose of being a demonstration building for passive house design principles and renewable technologies. It is the first educational building in Northern Ireland to have Passive House Certification. The building is distinguished by three key building standards:

- 1) Passive House Certified.
- 2) Building Research Establishment Environmental Assessment Method (BREEAM) Excellent.
- 3) Net Carbon Zero.

Whilst a combination of two of these sustainable criteria has been carried out in other parts of the UK, this was the first example of a combination of all three. This paper presents an overview of the post occupancy performance data since completion.

The key findings that are presented include:

- Monitoring data of the space heating demand to date.
- Overview of the indoor air quality (IAQ) and ventilation performance to date.
- Generation data of the solar photovoltaic technology.

Building Overview

General Information

The CREST Passive Pavilion has a treated floor area of 455 m². The Pavilion features large areas of glazing to the south that assist with solar gain and allow natural light to penetrate deep into the floor plan, reducing the amount of artificial light required for the exhibition spaces. The building incorporates solar control as design features with a brise-soleil on the south facing windows in the lecture theatre along with large overhangs (see Figure 1) allowing winter solar gain from the low sun and reducing the occurrence of overheating from the high sun in the summer months. The frame of the building is constructed using structural

engineered timber made from glued laminated timber. The building fabric for the walls and roof is constructed of timber in the form of Structural Insulated Panels (SIPs).



Figure 1: The CREST Pavilion with design featured solar control in brise-soleil and large overhangs.

Building Performance

Space heating Demand

Heating for the building is provided via an air to water heat pump, with under floor heating distribution. The Passive House Planning Package (PHPP) calculates the annual heating demand using both the annual method and the monthly method. The calculated total annual space heating demand is thus 13.0 kWh/(m²a).

- Monthly method 13.0 kWh/(m²a) or 5,902 kWh/a.
- Annual method 11.3 kWh/(m²a) or 5,138 kWh/a.

Assuming current standard electricity rates in Northern Ireland 1 kWh = £0.15, then the predicted annual cost of heating the building excluding standard charges should be in the region of £885 for a building with a floor area of 455m². This compares very favourably with the South West College (SWC) estate average of 103kWh/(m²a), which for a building of the same size would imply annual space heating costs of approximately £7,030. That represents an 87% saving on heating.

Monitoring data via the Building Management System (BMS):

- Year 1 recorded 11.6 kWh/(m²a) or 5,283 kWh/a.
- Year 2 recorded 12.1 kWh/(m²a) or 5,488 kWh/a.

The recorded performance of the space heating for Year 1 was 5,283 kWh/a. Again assuming current standard electricity rates [Power NI] 1 kWh = £0.15, then the annual cost of heating the building excluding standard charges in Year 1 was £792.45. The recorded performance

of the space heating for Year 2 was 5,488 kWh/a. The annual cost of heating the building excluding standard charges in Year 2 was £823.20.

This was a slightly better than expected performance in contrast to the predicted annual heating demand calculated in the PHPP. In addition to the monitoring, we know the corridor under floor heating zone is rarely active due to the full length south facing glazing running the length of the corridor. This was suggested as the main reason for the monitored heat demand being less than the designed heat demand.

Ventilation

The Building Management System (BMS) optimises the performance of the building. It controls and monitors the key services including ventilation, windows indoor air quality. It constantly gathers data from internal monitors (e.g. temperature, carbon dioxide, relative humidity) responding according to user settings and preferences. It is also linked to an onsite weather station which measures external temperature, wind speed and rainfall similar to a previous paper [Clarke 2015]. User experience of the BMS controlled motorised windows is negative. They have been prone to faults with two actuator brackets needing to be replaced at CREST. The programmed controls prevent opening with low external temperature and during rain providing difficulties to the facility management team.

Ventilation is provided by two passive house certified Mechanical Ventilation Heat Recovery (MVHR) units in the building. The auxiliary electricity consumption of the MVHR was monitored since the completion of the building. In Year 1 the total recorded was 415 kWh/a. In Year 2 the total recorded was 399 kWh/a. This was again slightly better than the PHPP calculated auxiliary electric demand for the ventilation system which is 431 kWh/a; however it was within 10% of this predicted figure.

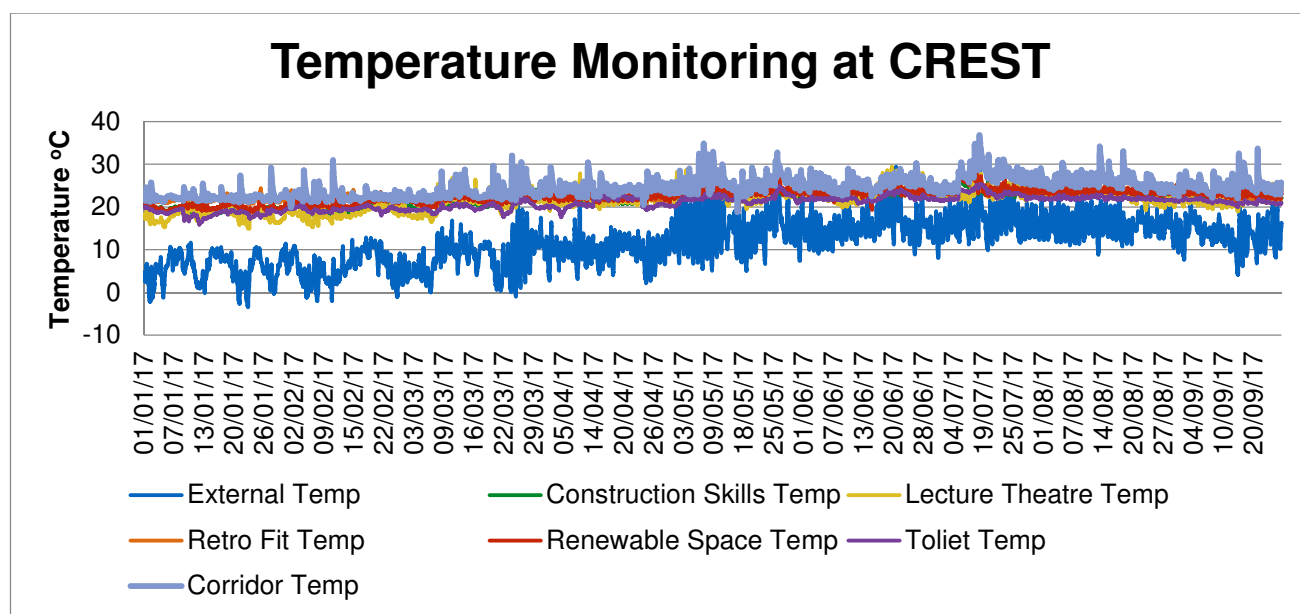


Figure 2: Temperature monitoring data from the CREST Pavilion along with the external temperature.

Early reports of overheating caused some alarm but this turned out to be due to a combination of control set points and higher than required heat pump flow temperature set points. We can see from the graph in Figure 2 that the indoor thermal comfort temperature range (16°C – 26°C) was maintained during this period despite some sub-zero external temperatures.

In the graph in Figure 3, monitoring data of carbon dioxide (CO₂) concentrations in parts per million (ppm) is presented from the four sensors inside the CREST Pavilion. We can see that the ventilation rates maintained moderate indoor air quality of 1,000 ppm with peaks typically below 1,200ppm [EN 13779:2007].

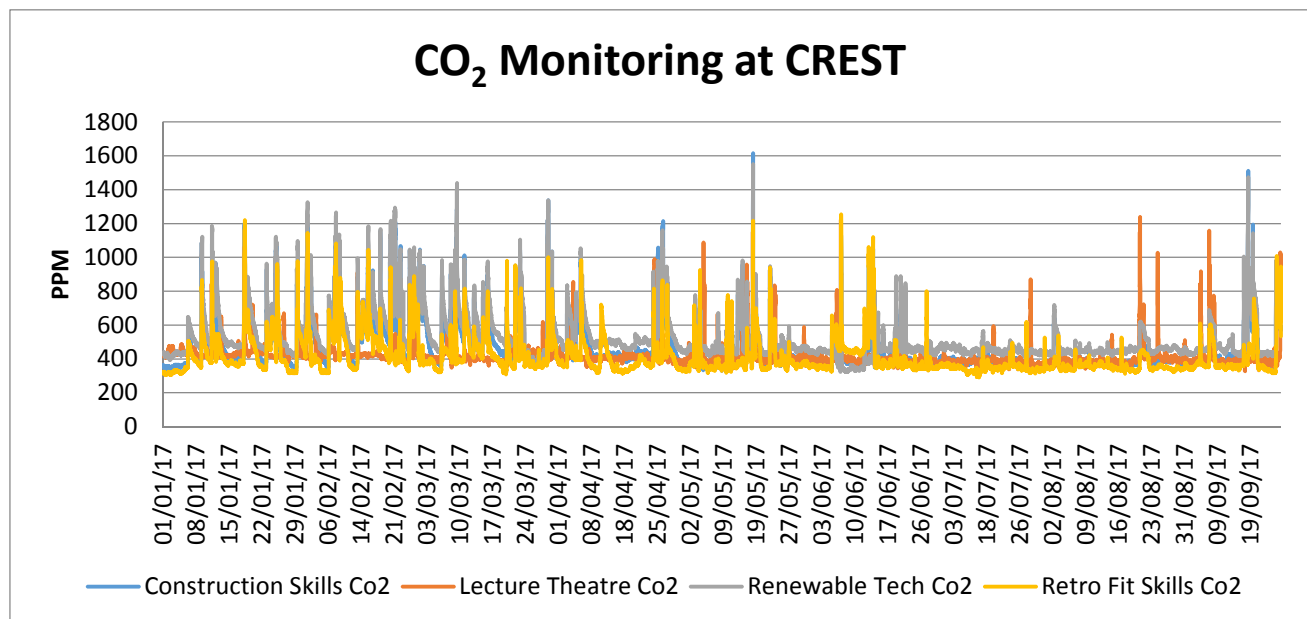


Figure 3: CO₂ monitoring data from the CREST Pavilion.

In the graph in Figure 4, the relative humidity (rH%) monitoring data is presented from the five sensors inside the CREST Pavilion. The monitoring data for relative humidity percentages was maintained within the recommend range of 35% -55% [Kaufmann 2016].

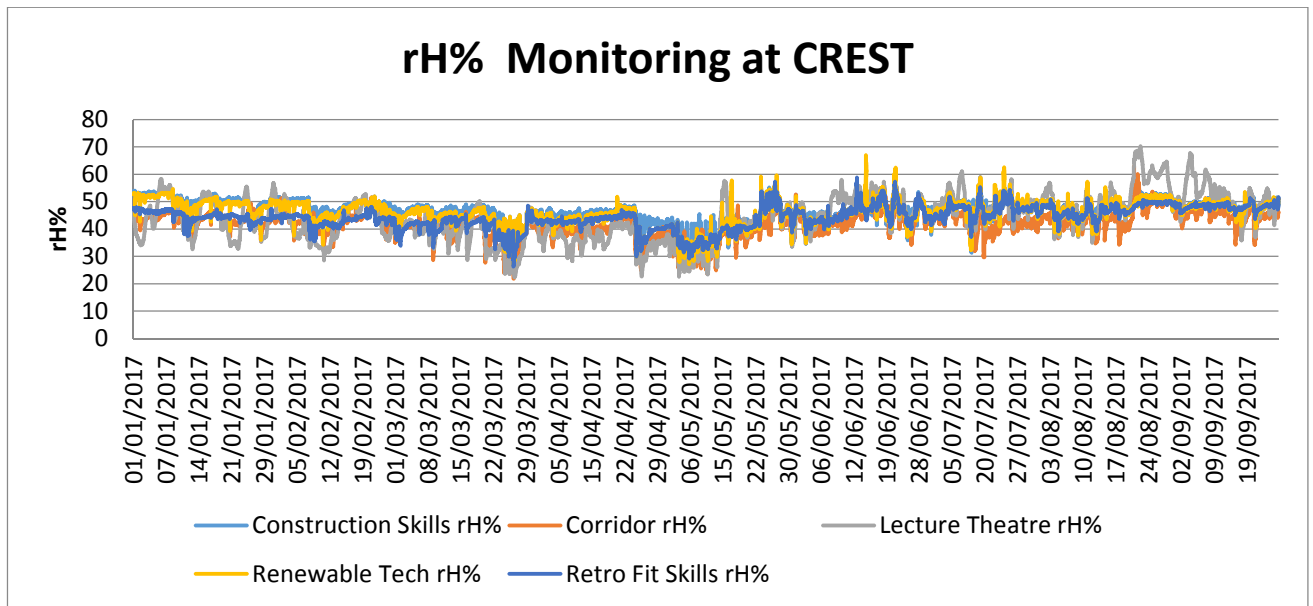


Figure 4: rH% monitoring data from the CREST Pavilion.

Energy

At CREST we embraced Net Carbon Zero as a logical step to achieve due to our low energy consumption as a result of achieving the Passive House standard. Others posed the question ‘Is net Zero the right target for buildings?’ [Grant 2012]. It is an excellent question however for CREST as we felt it was a good target for us with the nature and purpose of the building along with the backdrop of the future Energy Performance of Buildings Directive requiring all new buildings to be nearly zero energy buildings. Net Carbon Zero was achieved by virtue of the low energy demand and renewable energy installed in the building. There is a total 49kW of solar photovoltaic (PV) panels installed at the Pavilion. This is comprised of a 45kW robotic solar tracker and 4kW of static wall mounted panels.

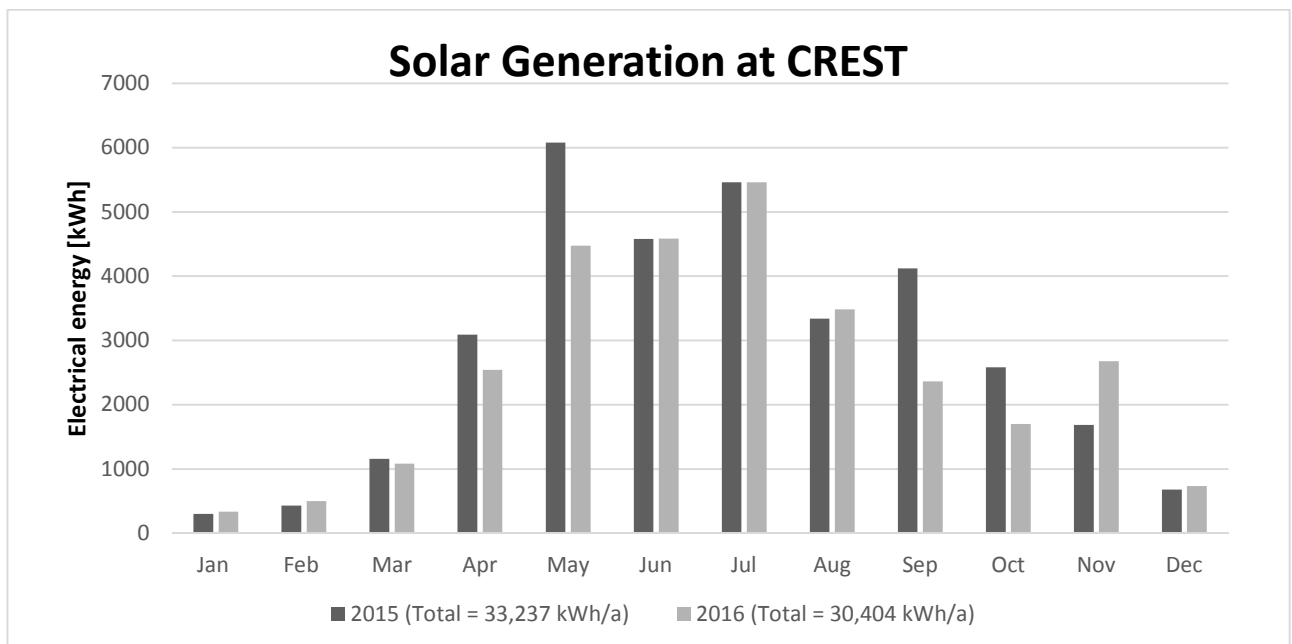


Figure 4: Annual monthly distribution of solar generation data from the CREST Pavilion

The PHPP has calculated the Primary Energy requirement to be 66 kWh/(m²a) for heating (air to water heat pump), domestic hot water, household electricity and auxiliary electricity. Primary Energy at 66 kWh/(m²a) equates to a total of 30,030 kWh/a. The monitored generation data for the robotic solar PV system and the static system at the CREST Pavilion in Year 1 was a total 33,237 kWh/a which offset the total primary energy demand and left a surplus of 3,207 kWh. In Year 2 the monitored generation data was 30,404 kWh/a which again offset the total primary energy demand and left a surplus of 374 kWh. This monitoring has demonstrated that the building can be considered to be net carbon zero because the actual annual generation output of the solar panels exceeds the total annual primary energy demand of the building [Grant 2012].

Conclusion

This paper focused on the CREST Pavilion performance data to date. These initial results of monitoring data have indicated the building is as calculated by the PHPP, if not performing slightly better than the calculated specific heating demand but within the range of the monthly and annual methods within the PHPP. This demonstrates that PHPP provides a robust design tool for accurate design and prediction of energy performance in the UK and adds to the growing body of evidence that the Passive House standard does not produce a significant performance gap between design and actual performance.

This post occupancy research also demonstrated that good indoor air quality was maintained within the recommended range for temperature, CO₂ and relative humidity. The BMS system recorded internal air quality every 15 minutes over each 24 hour period. This data was held for 10 days on the internal memory. This limited the recording of data and user experience has found the BMS system to be problematic, in particular the automatic windows. Similarly to [Bretzke 2012] and [Clarke 2015] we would advocate less sophisticated controls.

This research also highlights that the Passive House standard with the combination of excellent building fabric to reduce the heating demand coupled with renewable energy micro generation is an excellent vehicle for achieving zero carbon and near zero energy buildings.

The research for this paper has uncovered the need for some improvements in data collection and this will be addressed going forward with the PhD research. The BMS will be reconfigured to improve the collection of data and increased capacity added to record higher volumes of data including the IAQ and temperature profiling.

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CREST – Centre for Renewable Energy & Sustainable Technologies at South West College is one of the most sustainable buildings in the UK and Ireland, Passive House, BREEAM Excellent and Carbon Neutral building standards. This paper presents an overview of the performance since construction in 2014.

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